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FINAL TECHNICAL REPORT:
"TEST TECHNIQUES FOR HYPERSONIC IMPULSE FACILITIES"
NASA GRANT NCC 2-858

(PERIOD OF PERFORMANCE: APRIL 1, 1994 TO JUNE 30, 1995)

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Project and Task Description

Preliminary work for the development of a 1.5-inch shock tunnel facility at Ames' Hypersonic Free Flight Facility (HFFF) was already underway at the start of the present project. Under the guidance of ELORET Institute and NASA Senior Research Scientist David Bogdanoff, the present project was initiated to support development and operation of the 1.5-inch shock tunnel facility. This facility, smaller in scale and more cost-effective in construction and operation, was being implemented to support larger-scale tests in the existing 16-inch Shock Tunnel Facility. Once operational, the 1.5-inch shock tunnel facility would demonstrate various test techniques involving high enthalpy and pressure environments using pressure transducers, fiber-optic and stress/strain measuring systems.

The 1.5-inch shock tunnel utilizes two ten-foot and one three-foot 4140 steel ram accelerator tubes with 1.5- and 4.0-inch internal and external diameters respectively; each section was rated at 30,000 psi static loading. The ten-foot tubes, each cut into two-, four-, and six-foot sections, provide one or two gas driver tubes, a driven and accelerator tube in its final configuration. Test techniques would involve smooth burn and detonation of helium driver gas used to shock air, N_2, N_2O/N_2 or CO_2 driven (test) gas mixtures. The tunnel could be variously configurable as either a shock tube, reflected shock tunnel or expansion tube. Instrumentation systems would initially consist of eight high-pressure transducer sensors, with allowance made for installing additional systems as the need arises. The firing and data acquisition systems for the tunnel would be controlled either from the 16-inch control facility or from an independently dedicated facility, depending on the budget provided the facility.

The Research Assistant supported by this grant was to assist in the development of several of the subsystems required for installation and operation of the facility. Subsystems supported under the present project included the automatic gas feed, instrumentation and tube-mounting systems. Other required subsystems were to be developed by other research assistants assigned to this facility.

Although the primary objective of the present project was to assist in the development of the 1.5-inch Ames facility, a secondary objective was to design and implement a similar instrumentation system for the 3.5-inch shock tunnel facility at San Jose State University. Achieving the secondary objective would: i) provide a instrumentation, data acquisition systems upgrade to the SJSU facility; and ii) would allow the upgraded facility to function as a "sister" facility to the Ames 1.5-inch facility. Results of this secondary objective are also provided in this report.

The following is a chronological description of the work progress and results for the present project.

Work Progress and Results

The following section details the work progress and results for the duties specifically performed for the project as described above. It details each specific task for the period of performance covered by the grant period. It is to be noted that the project initiation was significantly delayed, until about July 1, 1994.

July - December, 1994 (Ames Facility only)

Tube cleaning and inspection:

Ram accelerator tubes, manufactured by an independent vendor, were delivered to the HFFF in September 1994. The first task following their delivery involved the removal of rust, dirt or any other foreign material attached to the tubes. After two weeks

of cleaning with alcohol and other cleaning solutions, work proceeded on the inspection of the gas feed, fiber optic and transducer ports. This required a thread fit and torque check at each port so as to ensure proper sealing of each nozzle and sensor along the tube. Incorrect threading of the fiber optic ports was found to exist on the 3' section. Although this section was still salvageable, this forced minor changes in the tunnel system arrangement.

Tube mounting:

It was tentatively decided to install the tubes and facility within Ames' Pressurized Ballistic Range (N-209), just outside the HFFF. This location would provide an independent test area with no interference from the facilities inside the HFFF, i.e., noise and EM interference. Also, the Pressurized Ballistic range provided enough room to accommodate both a firing and data acquisition room, each of which were very desirable. An additional factor, however, for choosing this location is that it would involve a required safety inspection of the range and additional funds needed to purchase new data acquisition equipment. Meanwhile, locations of the mounts (six total) for the accelerator tubes were examined and chosen. These mounts would be connected by large screws attached to holes, already drilled on rails located inside the N-209 facility. Since mounts within HFFF stores could not accommodate the shapes of the tubes, designs for custom-made mounts were needed. Once the design was completed, these custom-made mounts would be built by an independent contractor.

Gas Feeding System:

Nozzles, valves and fittings needed for the tubes were acquired from HFFF storerooms; each component required visual inspection and cleaning. The driver and driven gases were to be delivered by two "Little Richard" gas feed valves, both of which are air-actuated using electronic micro-switches. Parts required for these valves were also acquired from HFFF storerooms, and restored to proper working order. The last step of this stage involved hydrostatically testing each valve to ensure against leakage and to satisfy static loading requirements. This task required testing by qualified safety engineers.

Instrumentation:

The instrumentation system design initially chosen for the Ames 1.5-inch facility included eight pressure transducer sensors (PCB Model 113) porting to a Macintosh host computer using LABVIEW software for data acquisition and analysis. The pressure sensors were acquired from HFFF stores, but the additional costs needed to purchase a new data acquisition system (computer and software) necessitated a cost analysis of the final system. Since the allowable budget for this project was still being debated at the time, an alternative plan to port the sensors to the 16-Inch data acquisition system was also considered to provide a reduced-cost option. This option, however, would require the shock tunnel facility be located inside the HFFF, thereby depriving it of an independently operating test area.

January - March 1995 (Both facilities)

NASA-Ames Facility

During this time period, all significant 1.5-inch shock tunnel work was suspended pending resolution of the severe budget issues pending at the time.

SJSU Facility

The project's effort shifted to planning and developing an SJSU shock tunnel data acquisition system designed to be a "sister" system to the Ames facility. Two options considered earlier for the Ames facility included the use of an external analog to digital (A/D) chassis, similar to the 16-inch facility, or the use of a Macintosh / PC host with internal A/D board. Exploration of these same two options (external chassis vs microcomputer board DAS) was performed for SJSU shock tunnel system implementation.

April - June 1995 (Both facilities)

At the beginning of this period, NASA headquarters made the announcement that all funding for hypersonics research was canceled, effective immediately. There followed directly NASA-Ames implementation of this decision.

NASA-Ames Facility:

For the remainder of the grant period, the project's activities consisted of dismantling the current hypersonic facilities, e.g., HFFF and developing hypersonic facilities, e.g., 1.5-inch shock tunnel. This process under the present project included disassembly and component storage of laser measuring systems, gas feeding valves and test models. Equipments such as sensors, amplifiers and attenuators that were planned for use at the Ames facilities were being being considered for donated use at the SJSU facility, if approved by HFFF facility supervisors.

SJSU Facility:

Although the announcement meant there would be no operating Ames facility to which the SJSU upgraded facility would be related, work on options for an appropriate SJSU data acquisition system went ahead based on comparisons of the previously-defined Ames 1.5-inch facility options. The SJSU facility studies concluded that external chassis system acquisition costs, and complexity of maintenance and operation were such as to make this type of inappropriate in an educational facility. This decision then mandated a shift to a microcomputer data acquisition system design. It was found that a Macintosh-hosted system could not satisfy the required operating performance. Specifically, such a design based on commercially-available A/D boards would have an inadequate throughput data sample rate. The system design solution was chosen to be a modern, high-performance 486 host computer using a contemporary "snapshot" high-speed A/D board providing 1Msample/sec performance, and incorporating LABVIEW for WINDOWS software.

Use of Equipment Funds

The equipment funds provided by the project for use on the SJSU facility were used late in the project due to the uncertainty of future Ames developments, and yet a desire to use them very effectively. The funds were used to acquire several high-performance 486 computers, to upgrade an existing, suitable high-speed A/D board (with embedded software) to 486 compatibility and performance, and to acquire both an A/D board and corresponding LABVIEW software. In addition, two Powermac computers were acquired, with a view toward exploring their development as high-speed data acquisition systems as commercial boards for Macintosh computers evolve. These expenditures have positioned the SJSU facility for future exploration and development of a variety of 486-based and Macintosh-based high-speed data acquisition systems for shock tunnel implementation. In addition, project equipment funds were also used to acquire multiple strain-gage based pressure sensors, an instrumentation type of interest in the design of the Ames facility. These will be available for future implementation and development in the described microcomputer-hosted shock tunnel data acquisition systems.